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PETROGRAPHIC INVESTIGATION OF THE PORE STRUCTURE OF ALUMINA – SILICA REFRACTORY CONCRETES

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The results of a petrographic study of the pore structure of chamotte filler, the binder of alumina – silica refractory concretes, and stamped chamotte brick are presented. It is established that the pore structure of vibrationally cast alumina – silica concretes produced at the Semiluki Refractory Works consists mainly of round, closed pores.

The structure and chemical – mineral composition of a refractory article have a decisive influence on its chemical properties, specifically, on its interaction with corrosive agents during use [1]. The porosity of a material plays the largest role in the kinetics of the interaction process.

Pores are an integral part of refractories. They are located inside and between filler grains and in the binder, and they have a large effect on the properties of a refractory and, in consequence, on its working life span. Thus, a more porous material is less heat conductive, has lower mechanical strength but higher thermal stability, and is less resistant to corrosive agents (melts of slag, metal, salts, alkaline vapors, hydrocarbons) [2].

When refractory masonry comes into contact with corrosive agents, the agents penetrate into the pores in the refractory and interact chemically with it, causing the refractory to dissolve. Ultimately, the intensity of the dissolution process determines the working life span of the refractory.

The mechanism by which a liquid fills pores has a large effect on the impregnation of porous bodies by, for example, a slag melt or molten metal. This mechanism depends on the pore size. Large pores are filled as a result of capillary intake and small pores as a result of the condensation of the vapor of liquids present in them. For an essentially infinite amount of melt, its intake rate is directly proportional to the effective radius of the pores.

A minimal open porosity and a more uniform pore-size distribution minimize the penetration of molten metal into refractory materials [3]. The pore structure of refractories affects their resistance to corrosion by corrosive gases. Chemisorption can be observed, first of all, in dead-end and the smallest pores. The decomposition of refractories by deposits of solid carbon from the gas phase also depends on the microhardness [4]. Thus, the structure of refractories and its effect on their properties must be studied not only to evaluate the working life span of a refractory material but also to develop new types of refractories for specific working conditions in heat equipment when contact with corrosive agents can occur.

The present article presents the results of petrograhic studies of refractory vibrationally cast concrete articles manufactured at the Semiluki Refractory Works and chamotte filler and binder based on high-alumina cement, which were developed for use in the lining of a tin melt tank in float lines for the production of polished glass. With respect to chemical composition the concretes studied are mullite-silica concretes, whose Al_2O_3 content is 42 – 44%. The heat-treatment temperature of the articles is 400°C. A classical calcined material — chamotte brick from the Saratov Technical Glass Words, obtained by manual stamping from semidry chamotte paste with a clay binder (such bricks are used for the lining at the bottom of a tin melt tank in domestic float lines) — and a sample of imported Verral-40FTSC-40AT alumina – silica refractory for the lining of the melt tank were investigated for comparison.

The working conditions of the melt tank lining are very particular. Refractories decompose mainly as a result of interacting with tin and its vapors under reducing conditions and with the components of a protective gas atmosphere con-

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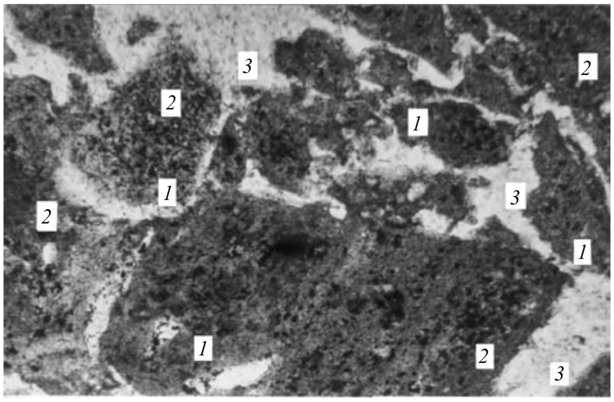

Fig. 1. Chamotte bottom brick for a molten tin tank (polaroids //, × 150). The general structure of the material: chamotte fragments *1* with fine opaque inclusions *2*, large number of communicating pores *3*.

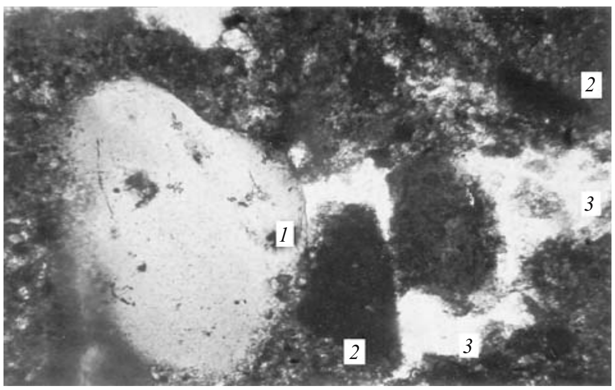

Fig. 2. Verral-40FTSC-40AT chamotte refractory (polaroids //, × 150). Oval-rounded fragments of high-quality chamotte *1* and binder *2*, large, angular, communicating pores *3*.

sisting of nitrogen, hydrogen with unavoidable entry of moisture, oxygen, and carbon monoxide [5].

Molten tin is distinguished by high fluidity, as a result of which there is a high probability that liquid tin will be drawn into the pores in the refractory. When it penetrates into a refractory a metal interacts chemically with the refractory, which ultimately results in the decomposition of the refractory. A refractory lining must be made of a material which is best suited for preventing defects from appearing in glass as a result of the decomposition of the lining refractory and for reducing the consumption of expensive metal.

The intake rate and depth depend not so much on the porosity itself as on the size and character of the pores and the number of channel pores. Consequently, an article for the bottom masonry must possess negligible channel porosity and gas permeability. The gas permeability depends not so much on the pore volume as on the pore structure and shape and the size of the porous channels, which, in turn, are determined by the technological parameters of the process used to manufacture the refractory: the filler particle size, the formation method, and the calcination temperature.

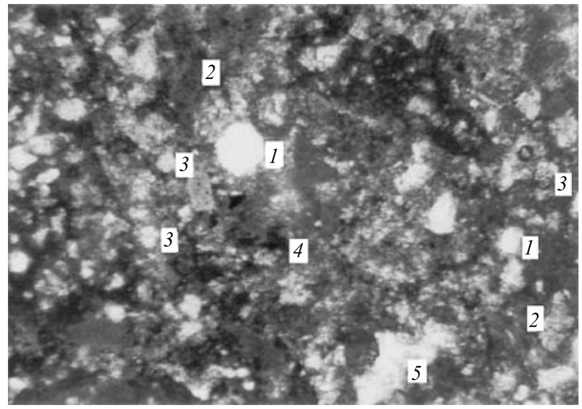

Fig. 3. Chamotte concrete (heat-treatment temperature 110°C, polaroids //, × 150). Pores *1* in the binder, chamotte particles *2*, calcium aluminate hydrate *3*, opaque clumps with alumina *4* and cristobalite *5* are observed.

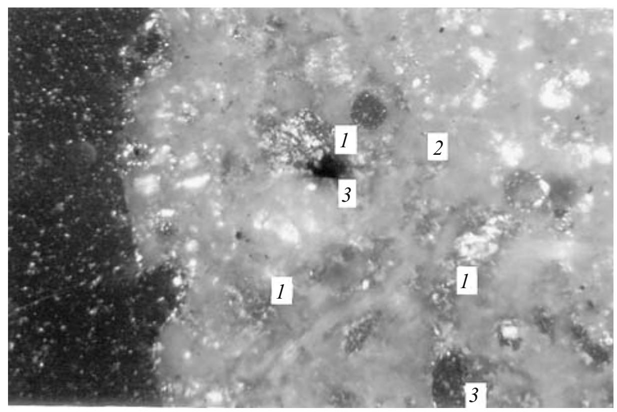

Fig. 4. Chamotte concrete (heat-treatment temperature 400°C, polaroids +, × 150). Microsilica clumps *1* in binder *2*, rounded pores of various sizes *3*.

A POLAM-R-211 polarization microscope was used for the investigations, which were performed in transmitted light using crossed polaroids in order to study the interference coloring of the components of the materials.

Thin sections were prepared using Done dial epoxy resin, whose refractive index is 1.545, as the binder. A study of thin sections of the calcined material of a chamotte brick showed that its porosity is expressed as a nonuniform distribution of voids with isometric and irregular shapes and small 1.5 – 2.0 mm cracks occupying 10 – 20% of the material. Pores with angular cross sections of various sizes (from 0.01 to 1.00 mm) and fine cracks between broken fragments of the chamotte grains are also present. Fine pores are also present inside grain fragments (Fig. 1). The imported refractory Verral-40FTSC-40FT (Fig. 2) has a similar structure: diverse pores, angular, ranging in size from hundredths to tenths of mm to 2 – 3 mm, i.e., quite large, which communicate with one another.

Figures 3 – 6 display photomicrographs of chamotte concrete material after heat treatment at 100, 400, 1000, and

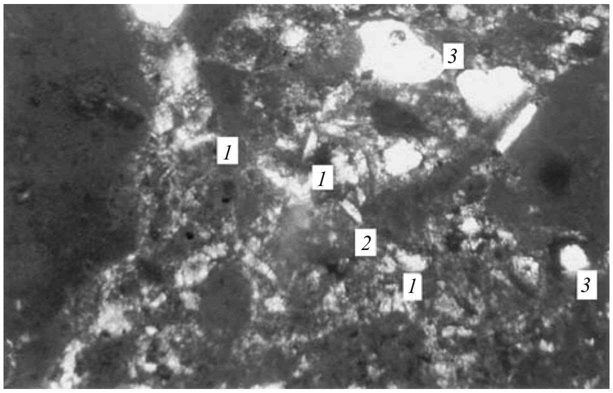

Fig. 5. Structure of the binder of chamotte concrete (heat-treatment temperature 1000°C, polaroids //, × 150). Crystals of calcium aluminates and silicates *1*, newly formed mullite within the binder *2*, oval pores *3*.

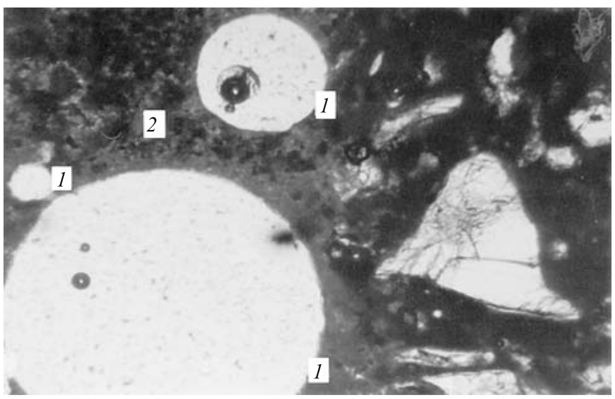

Fig. 6. Character of the porosity of chamotte concrete (heat-treatment temperature 1400°C, polaroids //, × 150). Spherical pores *1* in binder *2*.

1400°C. As one can see, the pore structure consists mainly of isolated rounded pores. This is due to the method of formation — vibratory casting from thixotropic paste. Oval and elongated pores are encountered less frequently. The pore size ranges from hundredths of mm to 0.05 – 0.20 mm. The pores are always isolated and usually have an ideally circular shape (see Figs. 3 and 5). The predominant transverse size of the pores is 0.05 mm.

Increasing the heat-treatment temperature of the material does not change the character of the pores much — basically they remain rounded right up to 1400°C (see Fig. 6).

In contrast to stamped chamotte brick, channel porosity is not developed in the material. The observed increase in the size of open pores as the calcination temperature increases to 1400°C is not threatening, since the pores remain spherical and rounded, and even if they are open, the penetrability of the material does not increase with an increase of the open porosity. An examination of the pore structure of the imported sample of refractory material under a microscope did not show any advantages of this material over domestic materials.

In summary, a comparative study of the pore structure of chamotte materials made by the classical technology and of the chamotte concrete material manufactured by vibratory casting from thixotropic paste showed that the pore structure of the chamotte concrete consists mainly of rounded isolated pores, which remain unchanged even at high heat-treatment temperature — a clear advantage over calcined chamotte materials. The fine-pore structure with a minimal number of channel pores indicates that the new material is promising for use in the lining of a tin melt tank.

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